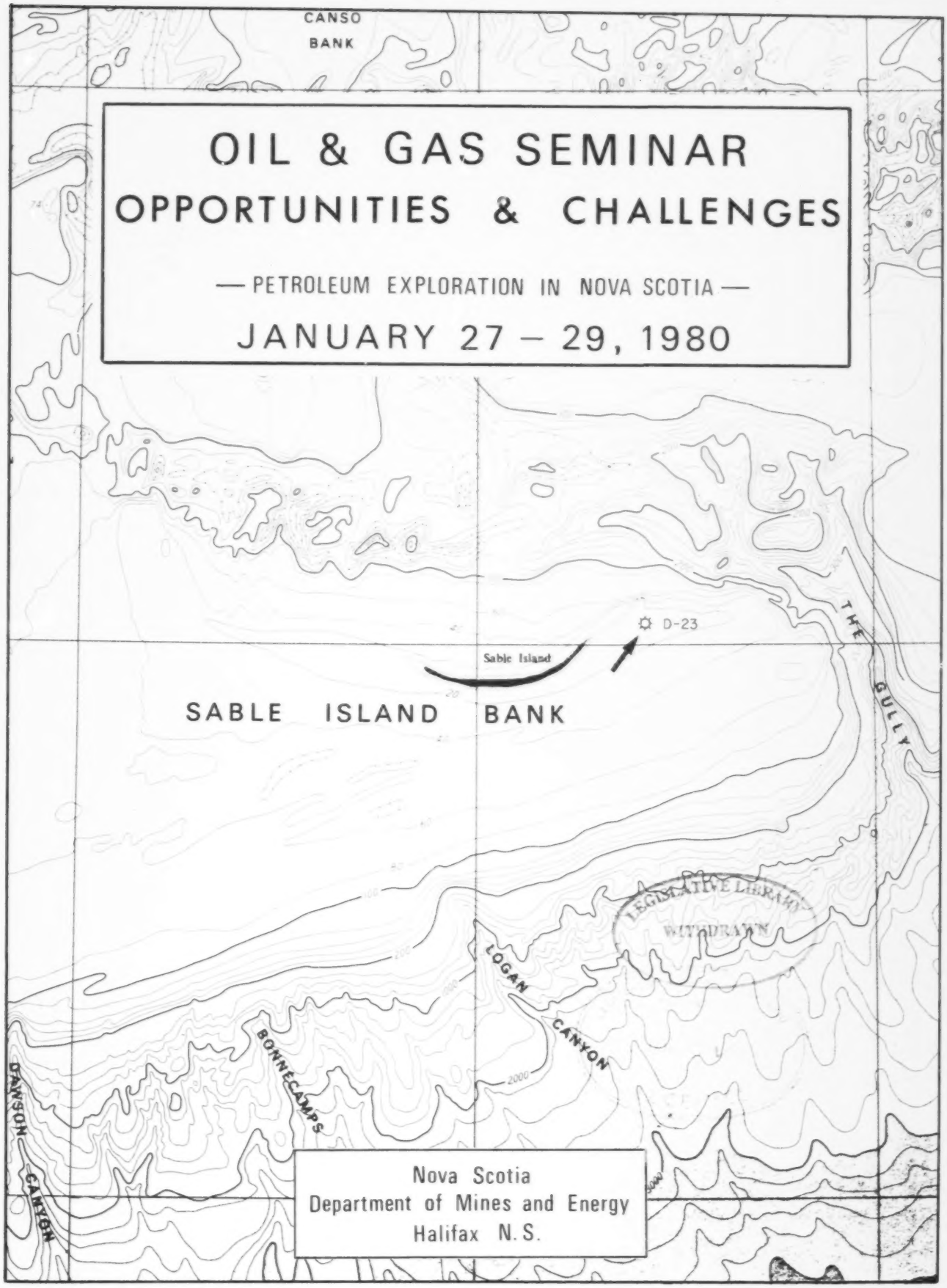

CANSO
BANK
OIL & GAS SEMINAR
OPPORTUNITIES & CHALLENGES
— PETROLEUM EXPLORATION IN NOVA SCOTIA —
JANUARY 27 – 29, 1980
D-23
Sable Island
SABLE ISLAND BANK
THE GULLY
LOGAN CANYON
BONNECAMPS
DAWSON CANYON
LEGISLATIVE LIBRARY
WITHDRAWN
Nova Scotia
Department of Mines and Energy
Halifax N.S.

CONTENTS

PART I

Oil & Gas Exploration

1) Licenses

2) Exploration Activity

3) Geological Setting

4) Department of Mines and Energy Role

PART II

Oil & Gas Information

1) Origin

2) Common Structures

3) Exploration Procedures

4) Development Procedures

5) Development Timetable

6) Technological Advances

For futher information contact:

Mr. W. Potter
N. S. Dept. of Mines & Energy
1690 Hollis St.,
Halifax, N. S. B3J 2X1
424-6732

Introduction

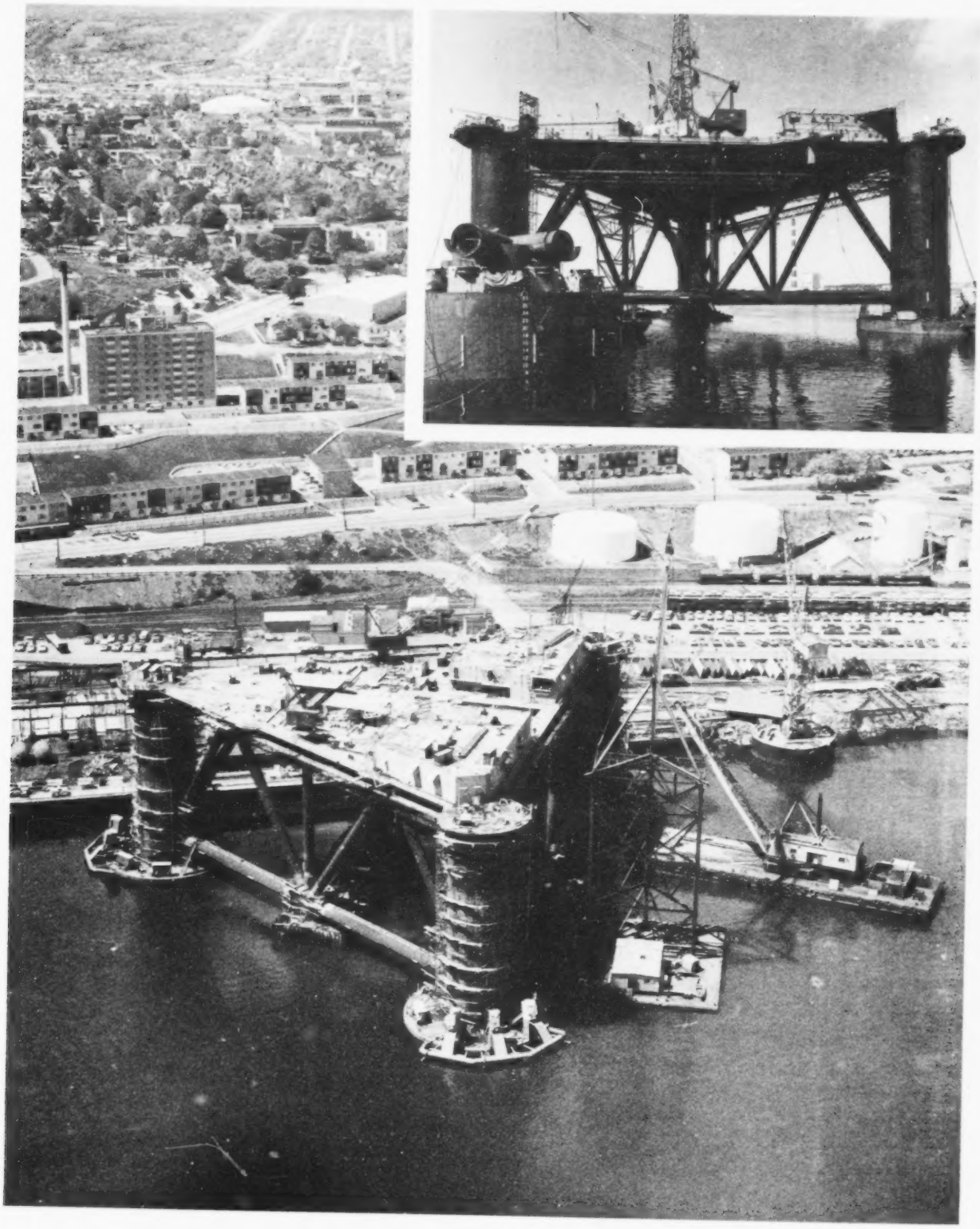
The petroleum industry began to look east in 1959 for a new source of energy and the Nova Scotia Shelf on the East Coast of Canada appeared as an exciting prospect. In that year Mobil Oil undertook an air magnetometer survey of the Sable Island area. In the following year they carried out their first seismic program over a 1.1 million acre exploration area on provincial license. In 1963 Shell Canada licensed 20 million acres from the province and by early 1965 the remainder of the Scotian Shelf was licensed to different companies. In 1971-73 the area under license extended well down the slope of the Scotia Shelf.

The area licensed off Nova Scotia is approximately 28 million acres and 8 million acres onshore, in the Bay of Fundy and Northumberland Strait. Exploratory drilling commenced in 1967 with Mobil Sable Island #1 and resumed in September 1969 when Shell Canada ltd., contracted the Sedneth 1 semi-submersible drilling vessel to drill on the Scotia Shelf.

To date 71 wells have been drilled by the several major companies, including Shell, Mobil, Chevron, Murphy, Union and Petro-Canada, in our offshore areas. Late in 1972, Anschutz Corporation spudded a 14,000' test in the Cumberland Basin, onshore, and thus began a renewal search for petroleum in the sedimentary environments throughout Nova Scotia. This hole was abandoned at 14,883' in September 1973. Of the 71 wells completed offshore, there have been five significant shows involving 13 wells. Six development wells were completed on the western tip of Sable Island to assist in defining the limits of the initial discovery and results were disappointing from that area. The most significant discovery has been the Venture D-23 well, 7 miles east of Sable Island, completed in late May of 1979 to a total depth of 16,223'. This well flowed at a combine rate of 40 mmcf/d from 3 zones between 14,000-16,000 feet.

The following outlines briefly the licensing system over the sedimentary basins under provincial jurisdiction, a summary of exploration activity to date, a brief geological summary of the potential hydrocarbon environments, and the role that the Department of Mines and Energy plays in the search for a new energy source for Nova Scotians.

Part II of this booklet is a summary of how oil is formed, trapped, explored for and produced. This part was made available through the Extension Department, Memorial University, St. Johns, Newfoundland.



Licenses

To ensure maximum benefit and proper management and control of all exploration activity under provincial jurisdiction licenses are required over all petroleum and natural gas exploration areas. These licenses are issued by the department in accordance with the Petroleum and Natural Gas Act and regulations thereunder. The smallest area that may be licensed is the reservation comprising 18 square miles, 6 miles east-west and 3 miles north-south. The fee schedule is outlined in the Petroleum and Natural Gas Act and varies for the type of license required, namely, land, submarine (open water) or a combination of both. Fees required are an annual rental and a statutory deposit guaranteeing that satisfactory exploration will be carried out.

Rentals for all types of licenses are $36.00 per reservation or fraction thereof for each of the first three years and $72.00 per reservation or fraction thereof per year thereafter.

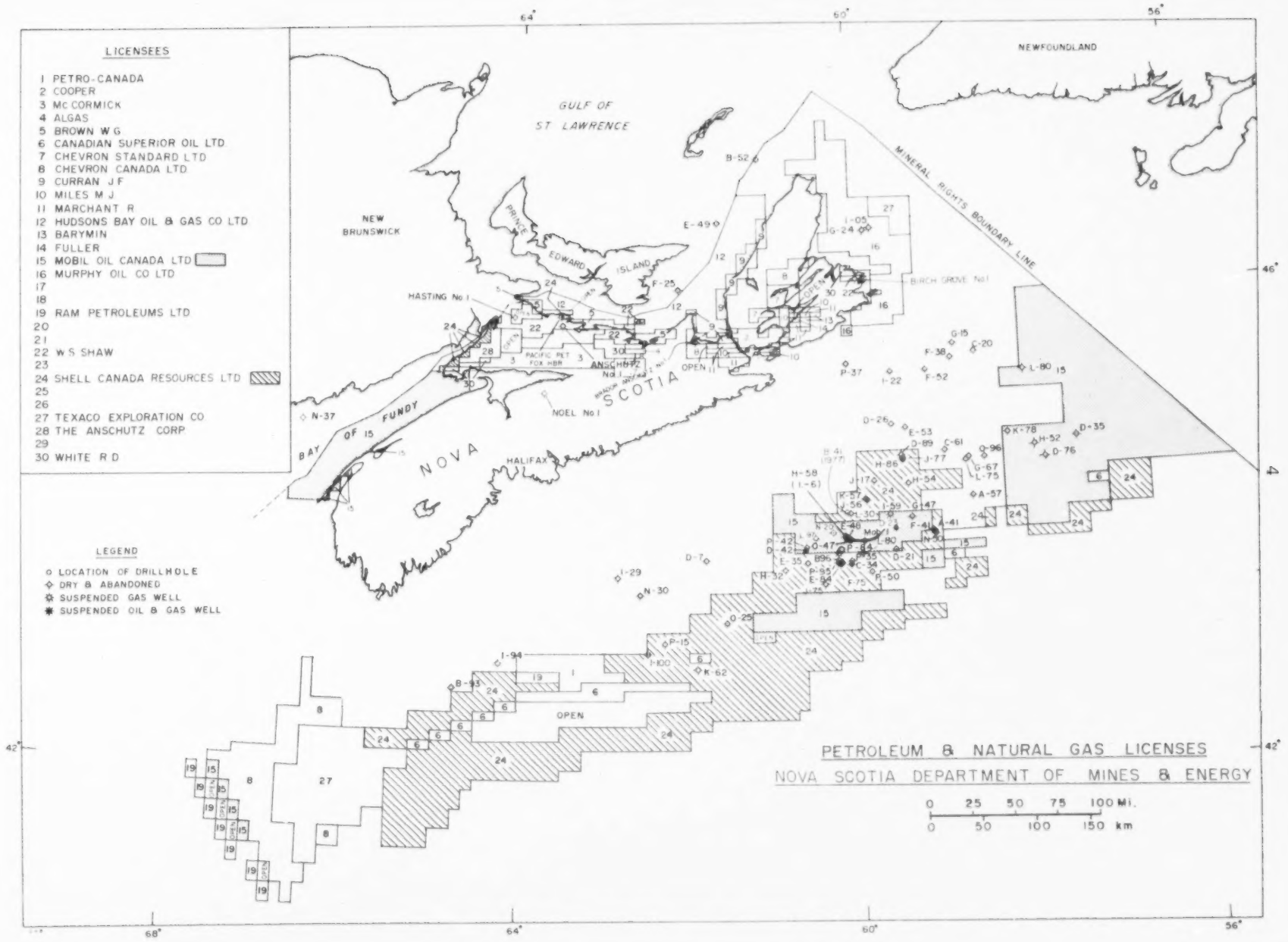
Statutory deposits vary according to the type of license namely:-

LAND

$576.00 per reservation for the first year
$918.00 per reservation for the second year,
$1386.00 per reservation for the third year,
$2304.00 per reservation for the fourth year,
$2880.00 per reservation for the fifth year and each further year of renewal as Governor in Council directs.

SUBMARINE

$864.00 per reservation for the initial term, years 1 to 3
$1728.00 per reservation for the second term, years 4 to 6
$2304.00 per reservation for the 7th year
$3456.00 per reservation for the 8th year
$5760.00 per reservation for each of the 9th to 12th years.


LICENSEES
1 PETRO-CANADA
2 COOPER
3 Mc CORMICK
4 ALGAS
5 BROWN W G
6 CANADIAN SUPERIOR OIL LTD
7 CHEVRON STANDARD LTD
8 CHEVRON CANADA LTD
9 CURRAN J F
10 MILES M J
11 MARCHANT R
12 HUDSONS BAY OIL & GAS CO LTD
13 BARYMIN
14 FULLER
15 MOBIL OIL CANADA LTD
16 MURPHY OIL CO LTD
19 RAM PETROLEUMS LTD
22 W S SHAW
24 SHELL CANADA RESOURCES LTD
27 TEXACO EXPLORATION CO
28 THE ANSCHUTZ CORP
30 WHITE R D
LEGEND
LOCATION OF DRILLHOLE
DRY & ABANDONED
SUSPENDED GAS WELL
SUSPENDED OIL & GAS WELL
GULF OF ST LAWRENCE
NEWFOUNDLAND
NEW BRUNSWICK
PRINCE EDWARD ISLAND
NOVA SCOTIA
BAY OF FUNDY
HALIFAX
MINERAL RIGHTS BOUNDARY LINE
HASTING No 1
NOEL No 1
ANSCHUTZ No 1
BIRCH GROVE No 1
PACIFIC PET FOX HBR
OPEN
PETROLEUM & NATURAL GAS LICENSES
NOVA SCOTIA DEPARTMENT OF MINES & ENERGY
0 25 50 75 100 Mi.
0 50 100 150 km
64°
60°
56°
46°
42°
68°

THER SUBMARINE

$864.00 per reservation for the initial term, years 1 to 3
$1728.00 per reservation for the second term, years 4 and 5
$2304.00 per reservation for the third term, years 6 and 7
$3456.00 per reservation for the 8th year
$5760.00 per reservation for the 9th year and each further renewal as the Governor in Council directs.

As can be seen from the Petroleum icense Map, almost all areas that are edimentary in origin and thus poten- ially hydrocarbon bearing are being held nd explored in the onshore and offshore egions by over 20 active petroleum com- anies. All licenses are issued by the epartment through the Registrar of Mineral ights. Applications for particular areas hich must be accompanied by first year entals are received, assessed, accepted r rejected depending on the individual ituation. Fees, rentals and work commit- ents vary with the type of license, be it ffshore, onshore, or a combination of oth, and the earliest dated application s given priority for acceptance of a iven license. Several areas now under icense and affected by subsequent inter- ational disputes have been placed in oratorium and exploration is not required ntil the dispute is settled. The second tage or development on a licensed area s to progress to a leasing agreement nabling the lessee to develop and produce ydrocarbons from the lease.

Exploration

"Small quantitites of petroleum have been eported in shows in several onshore locat- ons. The gypsum of Hants County in the eighbourhood of Cheverie contains portions trongly impregnated with it.

t Lake Ainslie, Cape Breton, the quantity howing on the surface of the water was so onsiderable as to have induced explor- tion, as long ago as 1874. Two bore holes ere put down. The first gave indications f oil but was lost at a depth of 650' y breaking of the rodd which could not be recovered. The second hole was put down to a depth of over 900' and gave better promise of oil, yielding, it is said, nearly 100 gallons, on the bore hole standing for several days. Further work was prevented by the want of funds. Altogether some $20,000 were expended."(Dept. of Mines Annual Report, 1874).

The search for petroleum in commercial quantities is by no means a new development in Nova Scotia. Events similar to the above mentioned continued throughout the last 100 years in the onshore sedimentary basins. Numerous holes from 100-10,000' have been drilled and abandoned. A major discovery has never been made onshore, although many holes had shows of oil or gas. Mostly, the various programs were suspended for lack of funds.

Using the latest technological methods available, exploration has again returned to Nova Scotia. Geophysical, geological and drilling programs have been and are being carried out with most interesting and encouraging results.

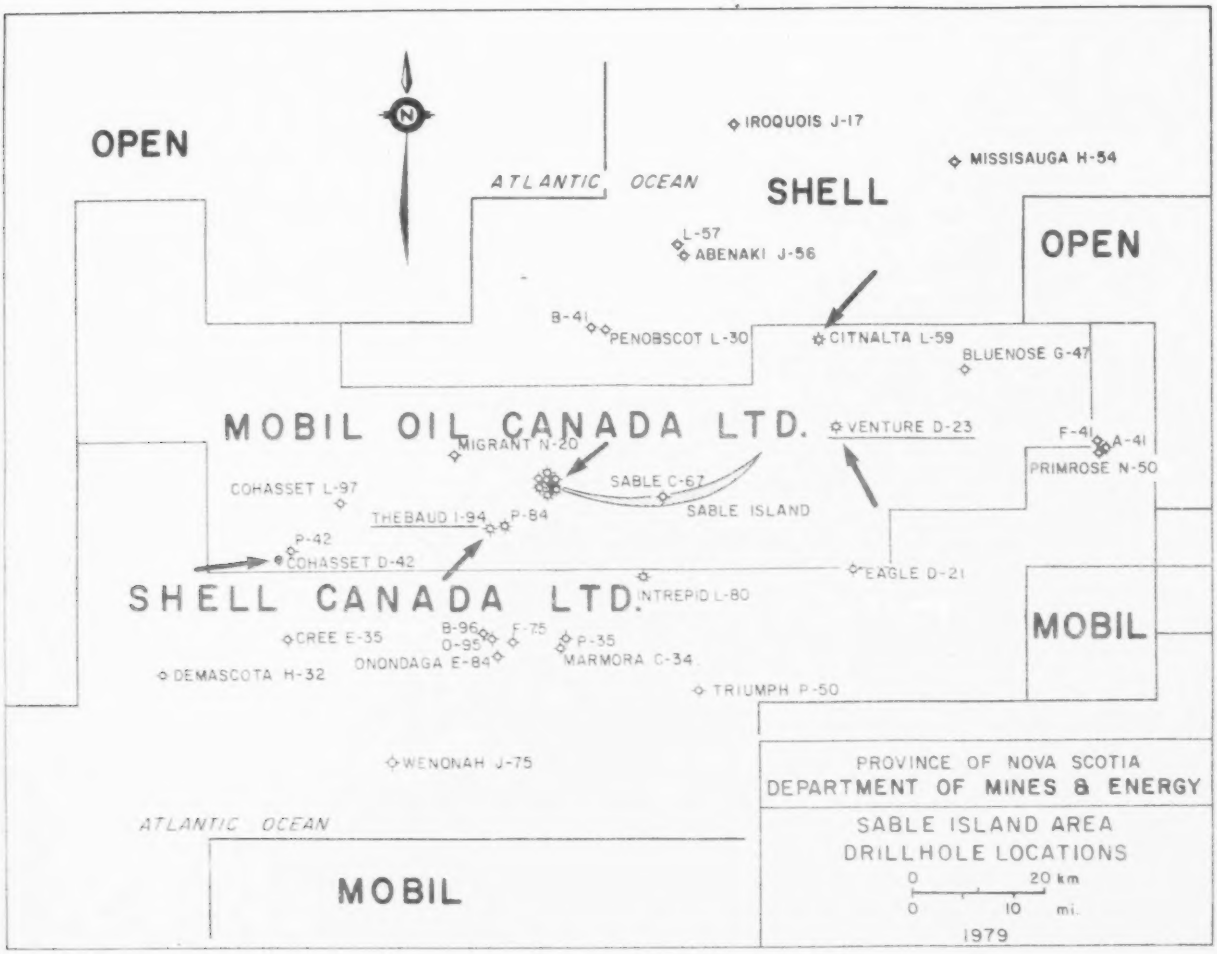
In the last decade several deep exploratory holes have been drilled onshore, with no new discoveries announced. These holes are drilled on structures outlined from detailed geological field work and seismic surveys.

The current drilling phase of offshore exploration began in 1967 when Mobil Oil drilled a 15,000' hole on Sable Island. Two years later Shell Canada began an extensive drilling program in conjunction with several seasons of marine seismic research. To date 71 wells have been drilled on the Scotia Shelf. Land based rigs were used for nine wells on Sable Island and semi-submersibles and Jack-up rigs for the 62 completed offshore.

The 71 holes completed covered a broad range of geological targets and were drilled in an area 60 miles south of Shelburne on the southwest to 60 miles east of Louisbourg on the northeast. Oil and gas shows were encountered in clastic rocks of Cretaceous age as well as clastic and carbonate rocks of Jurassic age.

The most encouraging results to date have been:

104-01191/


OPEN
IROQUOIS J-17
MISSISAUGA H-54
ATLANTIC OCEAN
SHELL
L-57
ABENAKI J-56
OPEN
B-41
PENOBSCOT L-30
CITNALTA L-59
BLUENOSE G-47
MOBIL OIL CANADA LTD.
VENTURE D-23
F-41
A-41
MIGRANT N-20
PRIMROSE N-50
COHASSET L-97
SABLE C-67
THEBAUD I-94
P-84
SABLE ISLAND
P-42
COHASSET D-42
EAGLE D-21
SHELL CANADA LTD.
INTREPID L-80
MOBIL
CREE E-35
B-96
O-95
F-75
P-35
MARMORA C-34
ONONDAGA E-84
DEMASCOTA H-32
TRIUMPH P-50
WENONAH J-75
PROVINCE OF NOVA SCOTIA
DEPARTMENT OF MINES & ENERGY
ATLANTIC OCEAN
SABLE ISLAND AREA
DRILLHOLE LOCATIONS
MOBIL
0 20 km
0 10 mi.
1979

1. Venture Structure Located 7 miles east of the eastern end of Sable Island. One hole completed to 16,233' encountered several gas bearing sandstones between 14,200' and 16,200' that flowed gas from 3 zones at a combined rate of 40 mmcf/d and 500 bbls of condensate per day. No firm estimate of potential reserves can be calculated and additional drilling is planned to confirm the presence of a major continuous gas reservoir.

2. Thebaud Structure Located 4.5 miles southwest of the western end of Sable Island. Two holes completed. P-84 produced 10 to 15 mmcf gas from each of several zones between 9,000 and 12,000 feet. I-94 drilled approximately 1.5 miles southwest of P-84 did not encounter the same pay section. It did however find several significant gas zones below 13,000 feet that will require additional exploration. No firm estimate of potential reserves can be calculated and additional drilling is necessary to confirm the presence of a major gas reservoir.

Significant Shows (Noncommercial)

1. West Sable Structure Seven holes drilled. The structure, developed from salt piercement to 12,000 feet, was found to be severely faulted. Estimated reserves do not warrant development at this time.

2. Cohasset Approximately 30 miles due west of the western end of Sable Island. Two wells completed on the structure. P-42 produced 1,000 bbls/oil per day from 124 feet of pay. Stepout well 1.5 miles northwest was dry and did not offer further exploration encouragement.

3. Citnalta Structure Located 10 miles northeast of East Sable Island. One hole I-59 drilled. Gas and condensate were tested from three thin zones at the combined rate of 10 to 12 mmcf/d.

4. Penobscot Structure Located 14 miles north of the west Sable Structure. Encountered several thin oil zones (untested) between 1,000 and 11,000 feet. A second well B-41 showed the equivalent zones to be wet or had pinched out.

5. Primrose Structure Located 50 miles east of East Sable Island. Three holes drilled. Tested gas in three zones (noncommercial).

6. Onondaga Structure Located 14 miles south of the West Sable Structure. Four holes encountered small quantities of gas (noncommercial). This first well E-84 showed the most encouragement.

7. Eagle Structure Located 12 miles southeast of the eastern end of Sable Island. Minor gas shows while drilling.

FUTURE PLANS

Mobil Oil has just completed a detailed seismic program in the immediate Sable area to further define the deep-seated structures that could hold the potential for commercial quantities of natural gas. It is hoped that the more sophisticated seismic equipment employed will allow the identification of structure traps in excess of 16,000 feet.

Mobil is currently negotiating for drilling rigs that will work in the shallow water around Sable Island and that have the capability of drilling and completing holes to 18,000 feet. Plans are being developed to allow exploration drilling to begin in June of this year. Initially this will involve delineation drilling on the Venture Structure as well as wildcat drilling on structures of similar characteristics.

Other major petroleum companies are reassessing the Scotia Shelf in light of this activity and it is expected that further exploration will follow immediately.

Drilling equipment used for onshore exploration is usually imported from Western Canada or Ontario as it is readily adaptable to the prospective locations. Originally a land-based rig was used for the Sable Island wells. However with the unique shape and size of the Island, the shifting sand problems and structural configuration of the underlying sediments, a special converted platform rig was mounted on 6' piles at the western tip of the island and drilled a series of six holes in a divergent circular pattern.

When the initial offshore phase of drilling began in 1969, Shell contracted a semi-submersible, the Sedneth 1 - a Dutch unit that has been drilling in Norwegian waters. At that time the first of four now completed semi-submersibles, was being built at the Halifax Shipyards primarily for use in Atlantic offshore. The Sedco H, I and J are now currently drilling on the Scotia Shelf and Grand Banks for the major oil companies holding licenses in these areas. The cost of these rigs has increased with new materials and cost of construction increases. In September 1972 Sedco J was launched at a cost of about $21 million, compared with $17 million for Sedco 1 in 1971 and $13 million for Sedco H, built in 1970.

These rigs are designed with the North Atlantic climate in mind, and have a 600' water depth drilling capacity. They are designed as a "Packaged Unit" and only consumable materials have to be delivered out to the rig on site. The latest ideas in safety design, environmental and pollution free operation, are integral parts of each vessel. A service boat is required to stand by near the drilling rig at all times. The drilling rigs are served continuously, weather permitting, with new materials and supplies from Halifax and the Canso Strait area where warehouses and supply depots have been established.

Geological Setting

Exploration companies for over a century have tried to interpret the geological history of the extremely varied sedimentary basins in the onshore and near shore areas of Nova Scotia. These basins which contain sediments suitable for the generation and trapping of hydrocarbons vary in thickness from 1000 to tens of thousands of feet and geologically have sediments that include sandstones, siltstones and shales from Pennsylvanian through Lower Mississippian in age. The Lower Mississippian is also noted for its thick sequences of evaporites and carbonates.

As can be seen from the license map, the areas are extensive and include the Minas Basin area, the Cumberland Basin, the Stellarton Gap-Pictou Basin, the Antigonish Basin, the Inverness-Mabou subbasin, the Lake Ainslie area, the Brad d'Or area and the Sydney subbasin.

From extensive geological mapping, geophysical surveys, diamond drilling and deep drilling for petroleum, the basins have been found to be complicated by the nature of deposition, age of sediments, erosion, structural movements contemporaneous and following deposition, flowage evaporites and many more stratigraphic and structurally complex geological problems. Dr. W. A. Bell's report "Petroleum Possibilities in Nova Scotia" gives a more detailed geological discussion on the various basins.

Numerous oil and gas showings have been located throughout the province by drilling or surface seepage and this has led petroleum geologists to recognize the potential of the area and to realize that the sediments are capable of generating hydrocarbons.

Each basin mentioned above is considered for detailed exploration with three main criteria in mind: (1) source rocks - rocks that at one time in geological history were capable of generating hydrocarbons, (2) reservoir rocks - sediments that have pore spaces adequate for storing or holding quantities of petroleum sufficient to be developed in commercial quantities; and (3) traps - rock configuration that through deposition of sediments or structural movement within the basin have created a trap for the hydrocarbons.

Oil has been found in similar geological environments in other parts of the world and with the world shortage in energy, a renewed effort is being made to fine economical quantities of oil in Nova Scotia.

The offshore areas of Nova Scotia that have thicknesses of sediments capable of producing hydrocarbons are very extensive and as can be seen from the license map, completely surround the province. On the Scotia Shelf, potential sediments extend east and west beyond the geographic extremities of the province and over two

hundred miles seaward. Drilling to date has indicated sediments younger in age and much more widespread than those encountered onshore.

All of the 32 million acres now held under offshore license have sediments favorable for the trapping of petroleum. Generally, the area contains thick sequences of mudstone, sandstone, shale, chalk and limestone varying in thickness and depositional characteristics over the entire shelf area.

The deepest hole to date has been Chevron Acadia K-62 on the Scotia Shelf that bottomed in carbonate at 18,000'. The oldest sedimentary rocks on the Scotia Shelf mapped have been evaporites, thought to be Upper Triassic in age. Above this are shales and limestones of Jurassic age, and sandstones, shales and an extremely consistent chalk marker that are Cretaceous in age. A relatively uninterrupted mudstone sequence of Tertiary age overlies this and an unconsolidated to consolidated sequence of mud and sand mapped as Recent, forms the remainder of the column. The above vary considerably from hole to hole and in various depositional environments (see cross section of Scotia Shelf).

North of the Scotia Shelf and east of Cape Breton, the offshore sediments again get older. Although the areas have not been drilled in the offshore Sydney Basin through to St. Pauls, it is believed the sediments are in many cases an extension of the onshore Sydney Basin and thus are from Pennsylvanian through Mississippian in age. The potential of the Magdalen Islands Basin south and west through the Northumberland Strait and including northern Nova Scotia is felt to be in a thick Carboniferous sequence that has many related evaporitic structures. This was evidenced by the Hudson Bay F-25 well that bottomed in Lower Mississippian at a depth of 9,876'.

Shows of oil and gas are very common throughout the various holes that have been completed and as was indicated previously significant shows have been reported in several holes on and near Sable Island (see Sable Island location map).

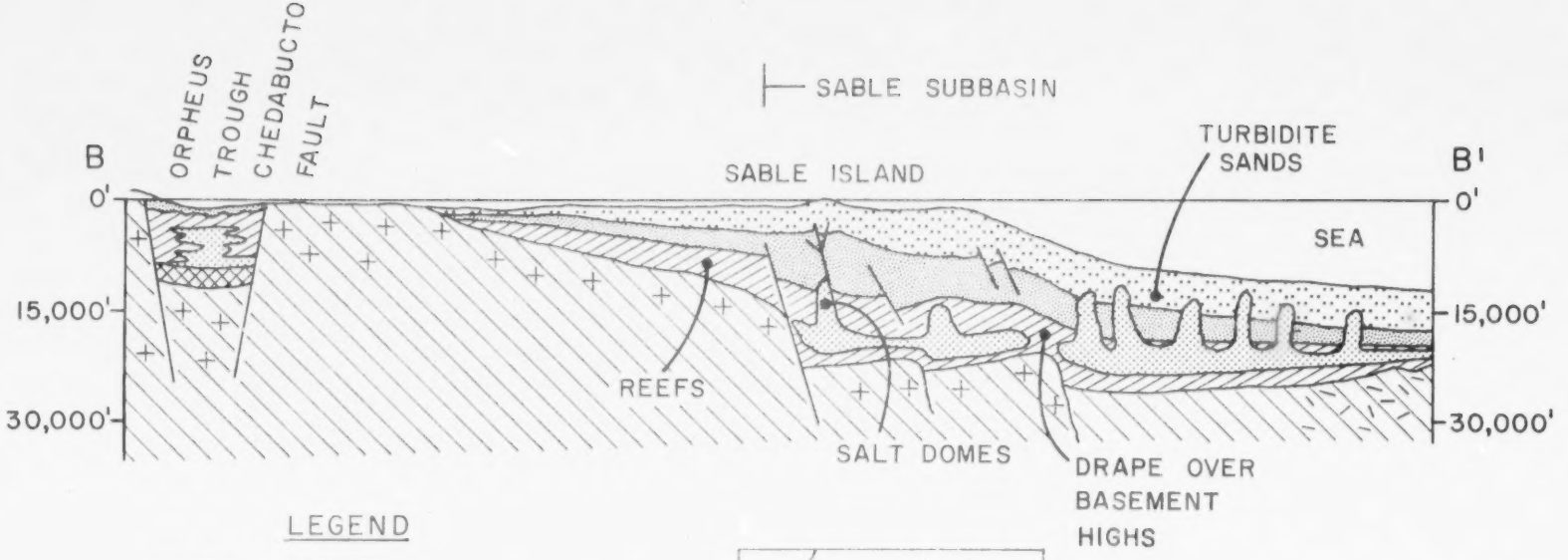
It might be noted that in our terms a show of oil or gas means evidence of oil or natural gas encountered while drilling. The degree or importance that is placed on a showing of petroleum depends on many factors including the type of sediment, porosity, permeability, depth encountered, thickness and extent of show, how it reacts to various quantitative and qualitative tests carried out at the surface and many more complicated associated factors.

Several areas on the Scotia Shelf have had significant shows and are having a more detailed appraisal undertaken.

Petroleum and natural gas fields in the offshore require a great deal in the way of reserves to produce than those of the onshore. Exploration and development costs are greatly increased in this hostile and deep water environment.

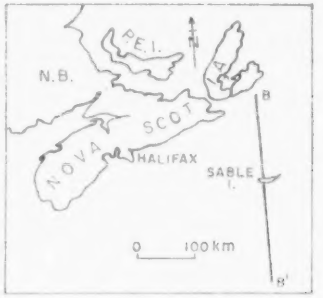
The offshore is indeed the last frontier and the vast potential of the Nova Scotian offshore makes an inviting challenge to the oil industry.

SCOTIAN SHELF



LEGEND

- CENOZOIC
- CRETACEOUS
- JURASSIC — SALT
- UP. TRIASSIC — RED BEDS
- BASEMENT (CONTINENTAL) — OCEANIC CRUST



0 40 80 km

The Department's Role

IN THE SEARCH, DEVELOPMENT, AND CONTROL OF RESOURCES

While major oil companies provide the money and expertise in the search for new petroleum fields the government also plays an important part.

As was mentioned earlier, licenses are issued through the Department of Mines and Energy to all companies wishing to acquire reservations to search for petroleum. These reservations are granted for a specific number of years with work obligations and requirements to be met at the end of each year. When an oil company begins an exploration program - be it geological, geophysical or drilling, a request to the provincial government is made, so that work completed can be applied to the licensed area. All vessels used for drilling require a rig license that is granted on the condition that this unit meets with provincial requirements. This applies to both land and sea based operations under provincial jurisdiction. Here the environmental, safety and mechanical problems that are interrelated come under close supervision by the department.

The companies are responsible for any environmental or pollution problems and prior to drilling must submit an oil spill contingency plan to the department. Inspections are carried out by the department in all the drilling and related operations that fall within the provincial licensed boundaries.

Drilling proposals, daily operational reports, abandonment proposals, logging and testing operations are sent to the department for consideration and approval. Geophysical and geological reports along with special environmental reports are received and approved by department personnel.

The geological staff examine representative samples and core from each well, and using downhole logs and well histories, keep an up-to-date geological appraisal of such things as source rock, reservoir rock, traps, individual structures, oil and gas shows, geopressured zones, and many other related geological and engineering problems. Two offices are maintained for the petroleum staff; one in Halifax and one in Stellarton. The Halifax office is an administrative office where all problems and business related to the petroleum industry are carried out. The office in Stellarton has been completed as a laboratory where cuttings and core are received and stored for all holes that are drilled for petroleum, salt or any related operation. Facilities have been provided for industry to examine cuttings and core that is on open file and includes samples from the various sedimentary basins throughout onshore and offshore Nova Scotia.

The present Petroleum Act and regulations are currently being redrafted along with an Oil and Gas Conservation Act and Regulations and a Pipe Lines Act and Regulations to ensure proper control and management of our petroleum and natural gas industry. A reappraisal of the various dues payable by licensees and lessees will be undertaken.

Control of Resources

On September 14, 1979, the Federal Government announced that control and management of the offshore resources would be the responsibility of the Province of Nova Scotia. This now means that the province can control the rate and method of exploration and development of any petroleum activities, either onshore or in the offshore areas. In order to regulate the current exploration programs and prepare for further exploration and development the province will have to enact legislation that will allow the petroleum industry to proceed at an orderly and acceptable pace and, at the same time, see that maximum benefits are obtained by Nova Scotia for this nonrenewable resource.

The province is preparing a new petroleum act and regulations that will encompass all aspects of exploration and development including permits, leases, land sales, rentals and royalties as well as developing the geological and engineering expertise to manage this resource, in light of the technological advances that have been developed elsewhere in the world.

As development progresses, a conservation board similar to the Alberta Energy Resource Conservation Board will be established. It will be responsible for conservation, exploration and production procedures, safe and efficient operations, rates of production, well spacing, defining resources and regulating the day to day activities of the industry.

By gaining and maintaining control of our petroleum resources the economic and social impact on Nova Scotia will be significant.

Along with the present Petroleum Act and Regulations currently being redrafted, Oil and Gas Conservation Act and Regulations and a Pipe Lines Act and Regulations are also being prepared to ensure proper control and management of our petroleum and natural gas industry.

The tempo of oil hunting is ever on the increase and as jurisdictional and administration problems between nations and within nations are sorted out, the Nova Scotia Department of Mines and Energy will be ready to play its role in helping industry to solve the energy crisis.

PART II

The Story of Oil and Gas

"Courtesy of Memorial University Extension Department"

What it is ....

Petroleum (rock oil) is a general term used to include all generated and commercially produced hydrocarbons from natural gas (methane) to crude oils and solid (asphaltic or paraffin) residues. This encompasses a tremendous range of molecular structures with a large range of physical properties all combined with numerous impurities.

How it is formed ....

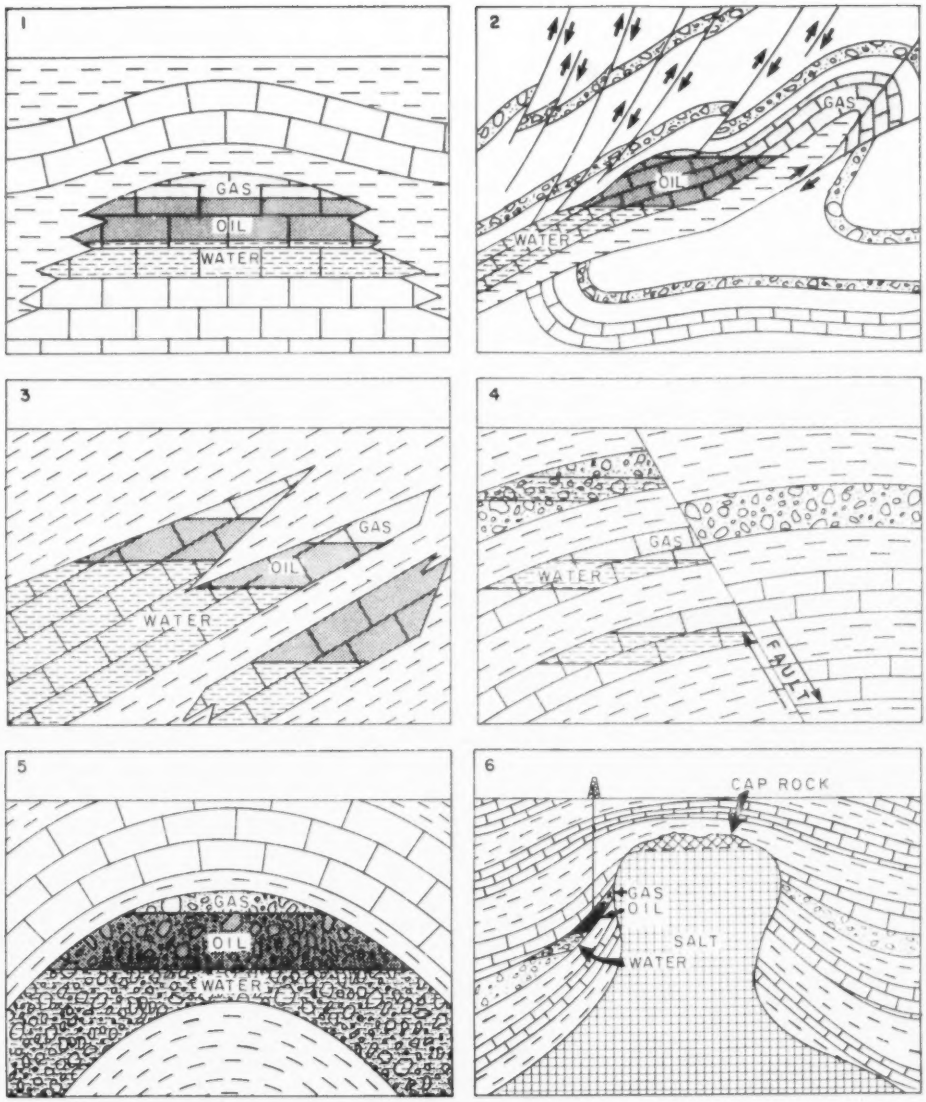
Petroleum is always found in, or associated with, sedimentary source rocks which, as newly deposited sediments, contained an abundance of plant or animal remains (organic material). The actual processes that took place to change organic remains into complex and varied hydrocarbons are only partly known because the time element - thousands of years - is not reproducible in laboratories. Evidence indicates that plant life is probably predominant as a basic contributor over animal life.

When it was formed ....

Since Cambrian time (550 million years ago), life forms have proliferated with the result that commercial petroleum is found in sedimentary rocks of all ages, in generally increasing quantities, up to recent times. And, that petroleum accumulated in various areas of the world during different ages is a result of the environmental conditions. In many areas accumulations from different ages are superimposed in rocks that vary in age by more than 200 million years. Even "new" rocks of the Quaternary Period (the last one million years) contain petroleum oils and gases, but only in few cases have these had time for migration into suitable reservoirs from which they can be recovered commercially.

How it is accumulated ....

To be recoverable, hydrocarbons must leave their disseminated and miniscule state in the fine grained source rocks and move into porous sands, limesands or fractured rocks (resevoirs), where they are concentrated and susceptible to being withdrawn through drilled holes. The mechanism of movement or migration of the hydrocarbons is largely unknown. What is known is that this movement is aided by the presence of water (usually salt water) in the sediments, and by compaction (squeezing), a result of burial under additional sediments.



TYPES OF TRAPS FOR OIL AND GAS

1. Limestone reef
2. Reservoirs in folded and faulted strata
3. Stratigraphic trap
4. Displacement of rock layers along a fault.
5. Anticlinal trap.
6. Salt dome trap.

LEGEND

- Sandstone
- Carbonate
- Shale
- Salt
- Gas
- Oil
- Water

NOTE
Fig. 1 to 5 from Our Petroleum Challenge, The New Era, 1979 and Fig. 6 modified from K. K. Landes, 1959.

This is illustrated by the accumulation of billions of barrels of oil or of trillions of cubic feet of gas into relatively small volumes of reservoir rock which contain our present giant fields, and the many smaller accumulations down to the uneconomical one-well "discovery".

The movement of hydrocarbons into a porous reservoir is only the first step, however. The migration will continue in the porous formation until it escapes to the surface, as at the Athabasca, Canada, tar sands, or is retained below by some subsurface barrier called a trap. The shapes and styles of traps are many but are usually related to the geological history of any particular area. The common element in all traps is that a further migration or flushing (by water) of the hydrocarbons toward the surface is prevented by overlying impermeable formations - as an inverted dish will retain air when immersed in water.

A further requirement of the trap is that it be preserved. Trapped oil and gas can be lost by faulting, as at the Santa Barbara Channel where seepage to the seafloor is slow but continual. It is very possible that more oil and gas have been thus "lost" during geological time than have been preserved in traps so far discovered.

How it is found ....

Oil and gas are relatively inert with no particular qualities that allow any specific measurement from a distance. The geologist and geophysicist use both "direct" and "indirect" methods to discern the geological structures in the subsurface which could comprise a trap for accumulation. Strictly geological methods mean a study of the surface rocks, or seafloor beds where exposed, and/or a study of subsurface rocks from the results of drilled holes. Geophysical methods include measurements of magnetic or gravity forces, radiometric or electrical characteristics, or acoustic (sound) wave propagation.

The last, called seismic, is the predominant method and has been in use for fifty years. For "offshore" (watercovered areas), it is the primary forerunner to pinpointing drilling locations. Basically it is a simple principle - initiating a sound (acoustic) wave at the surface and recording the elapsed time of echoes from the various reflecting rock strata at depth - the longer the elapsed time from impulse to return of reflection, the deeper the particular bed lies below the surface. Thus a tilted (dipping) bed will give an increased time of reflection as the recorder moves from where a bed is shallow to where it is deeper. Intermittent recordings obtained along a line are processed into a continuous profile which gives a graphic portrayal of those beds that generate reflections of the acoustic wave. .....

In a general sense, the profile shows the rock layers and their deformation by folding, faulting or piercement by salt or shale intrusions. By using a grid, or network, of such profiles and following a specific reflection, a contour map of subsurface structure is constructed - much as a topographic map of earth's surface is made. (The topographic hills and ridges of the surface map are similar to domes and anticlines in the subsurface while the valleys between are similar to the synclines. A sharp cliff or locally steep slope is akin to a fault).

Such a map, or maps indicate structural domes, anticlines, faults, and other features which could form traps for hydrocarbons. The actual depths at which these maps are made may vary from a thousand feet to more than 20,000 feet below the surface, depending on the thickness and the acoustical "transparency" of the column of sedimentary rocks and the estimated depth to potential oil or gas bearing formations.

It is, of course, necessary to know the surface positions from which all the recordings are made so the locations of possible drill sites can be relocated with accuracy. This is done on the recording boat by radio positioning from known stations on shore or by using the earth satellites as they traverse overhead.

Acquisition or Permission ....

Before drilling an exploration test, the rights to the area must be legally aquired ..... In foreign areas, rights are acquired from the appropriate national agency, either in direct negotiation for a concession as in the Middle East waters and Far East areas, or by competitive bidding as in the North Sea and some of the Mediterranean area. Such exploration rights or leases generally carry specific provisions such as time, work performance participation if production is found and marketing.

If all signals show "go", a drilling contractor is found who has the suitable equipment for the particular water conditions and proposed depth of the hole. The location is determined by geologists, geophysicists and management.

In U. S. waters it is necessary to conduct an "archeological survey" of the seafloor to assure that unnatural obstructions, such as prehistory cultural sites (occupied when ocean levels were lower than at present), wrecked ships, etc., are not present.

Once the area is declared clear, the drilling contractor will come in with the necessary equipment.

If the well is located in relatively shallow water, a jack-up drilling rig may be used. This vessel is floated to the site, and its legs lowered so that it sits on the seafloor and only its drilling deck and equipment are above the waves. Because it actually sits on the sea floor, the depth in which it can be used is limited.

In deeper waters, the drilling contractor must turn to drill ships or semi-submersible drilling barges.

Drill ships are exactly that - ships to house a drilling rig on its deck. The ship reaches the site, is anchored in position and carries out its drilling duties through its hull.

Another common drilling vessel is the semi-submersible drilling barge. Displacing as much as 45,500 tons of water, it may equal a battleship in weight. To operate, it is moved into position, and held in place by anchors. Then the hull is submerged so that part of the vessel sinks below the surface with the drilling deck remaining above. Because the area at the water line has only a few columns its battering about by hostile winds and waves is minimized.

Once the drilling vessel is in position operations can begin. A conductor pipe, 26 to 30 inches in diameter, is driven 100 to 300 feet into the seafloor and cemented. Drilling then begins. The drill bit cuts a hole about 22 inches in diameter and between 1000-2000' deep, a 20' pipe is lowered into it and cement is forced between it and the wall of the hole. A blowout preventer stack is installed to contain accumulations of gas or oil that may be encountered in further drilling. More pipe of smaller diameter may be cemented into place as the hole is deepened.

Now, drilling mud becomes of utmost importance. This special mixture of clay, water and chemical additives circulates through the drill pipe and cools and lubricates the rotating bit. The mud flows through the drill bit to wash cuttings back to the surface (providing information about the various formations being cut), cools the bit as it rotates, and holds the pressure against the various formations.

During the drilling operation core samples may be taken to obtain information on the exact nature of the strata through which the well has been drilled. This is done in one of two ways. An assembly may be attached to the drill pipe and lowered into the hole so samples are collected in a cylinder. Or projectiles may be fired into the wall of the hole at certain depths penetrating the sides of the wall and returned to the surface with the sample inside. The latter method is used after electric log surveys have been completed.

Gas and oil can at times be detected at the surface by analyzing the returning mud. However, because the gas and oil sometimes cannot be detected in the mud, and in order to determine the precise depth location of the hydrocarbons, an electrical well log is taken.....

By lowering electrodes into the hole on an insulated cable the electrical properties of the different formations are recorded at the surface.

This device records the porous versus the nonporous formations, and the electrical resistance of the formations. For example, sand-

stone saturated with salt water has a low resistance, but sandstone filled with oil and gas has a high resistance.

In those zones where favorable conditions are indicated drill stem tests will be conducted. Samples are taken from each zone and the pressure and flow rates monitored.

If it is determined that the reserves of this discovery well are of such an amount as to provide enough money to pay for further development plus yield a profit, engineering tests will begin.

Production casing will later be inserted into the hole. This will prevent the hole from caving in, control the flow of fluids between formations, confine the production to the specific area indicated to contain hydrocarbons, and permit the installation of equipment necessary for production.

The drilling contractor will then drill a series of confirmation holes to delineate the field. All the data from these tests, electric logs and samples are combined with the geological and geophysical maps, the extent of the producing area and the volume of oil and gas calculated, and an estimate of producible reserves is made.

Studies are then made as to the number of producing wells to be drilled, their spacing, the number and locations of producing platforms to be installed, and how the product is to be stored and transported to shore.

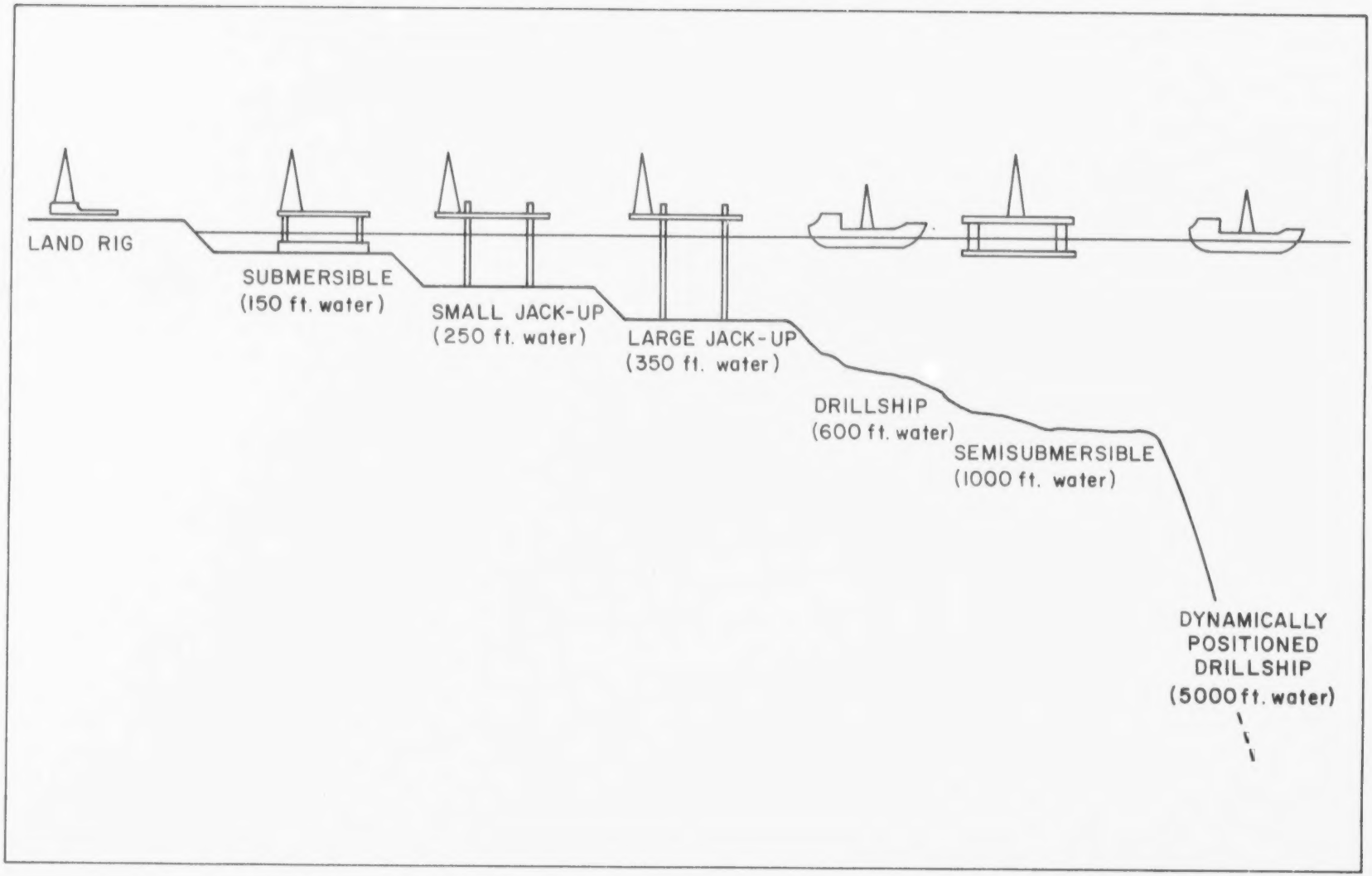
It should be pointed out that exploratory drilling will continue even after the development of a field has begun, and will be carried on for many years simultaneously with development work.

Producing the Hydrocarbons .....

Once the precise nature of the field is determined - oil or gas; its location; weather conditions of the area; the function to be performed and; if a drilling platform is used, the number of wells to be drilled from the offshore structure are determined. Engineering work begins utilizing civil, mechanical, electrical, chemical and instrumental engineers for the various aspects of the project. Marine engineers calculate data necessary to launch and set the structure in place once fabricated. Draftsmen carefully translate engineering calculations into a technical picture called drawings.

By using directional drilling techniques one platform can produce as many as 50 wells. This offshore structure, or platform as it is called, consists of a jacket pinned to the ocean floor by piling. On piles which extend above the water and which are braced by the jacket is placed a deck station. On this deck may be whatever may be required at the location .....

Because offshore structures must first withstand the horizontal forces of winds up to hurricane velocity, and waves as high



Typical evolution process for offshore mobile drilling units.

as 100 feet or more, probing research must be done into the environmental requirements of the structure. Design criteria are exacted for stresses and member sizes of the components of the structure. When the configurations of steel compute to the requirements of man and regulatory agencies, final drawings can be prepared for use by the fabricating yards and material can be ordered.

What the engineers have determined in their work is the most practical and economical way to achieve the customer's needs. It is a time of consuming process. The prodcedure might be simplified, if not hastened, if each structure were like the one before with only minor changes in requirements needed. Such is not the case, however, for each structure is unique. Each set of variables must be studied and resolved before one step in the design phase can be completed and the next begun.

After the drawings have been sent to the fabrication yard, actual work on the structure will begin. Materials must be moved from the fabrication yard inventory or purchased from steel mills. Operating companies must order structures well in advance. The time needed in the actual fabrication of a structure varies from 4 to 12 months depending on the size and complexity. These giants are as tall as skyscrapers, and like their on-land counterparts construction is a step by step process. Patterns are laid out, steel cut, tubular members rolled. Each joint must be prepared, fit into position, welded into place, and mated individually with another component.

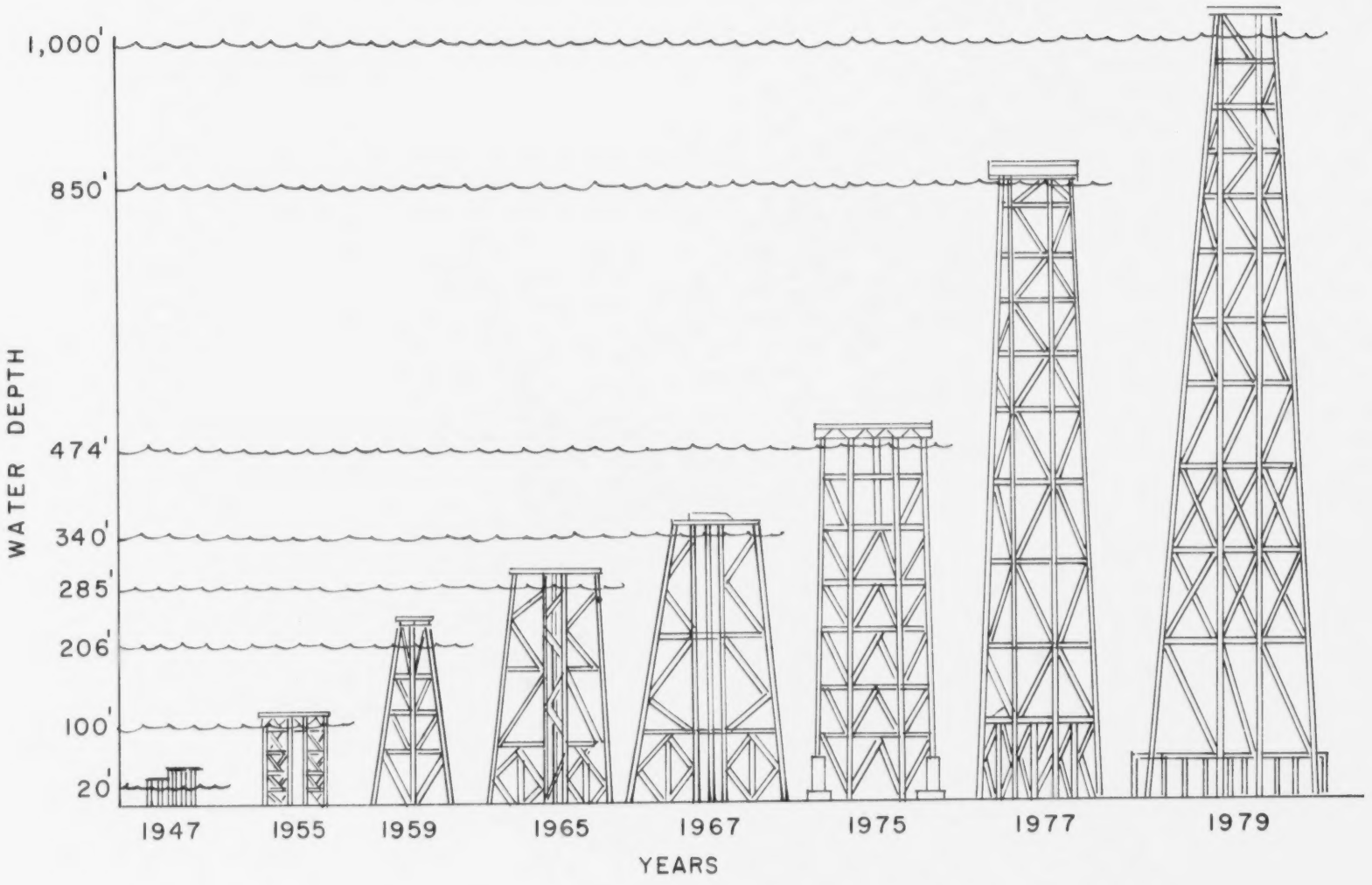
The components of each structure are fabricated into the largest possible units that may be economically and expeditiously transported from the fabrication yard to the job site. So doing minimizes the time at sea that erection operations are exposed to weather delays and the resulting increased costs.

Once the jacket is completed and its accompanying deck sections ready, it is pulled from the shore onto a barge that transports it to the installation site and slides it off onto the sea, where giant derrick barges lift and position the new man-made real estate. The giant bases of the structures, of jackets (templates), will sit on the seafloor. It is these templates with piles driven through their legs that will absorb the forces of perpetual movement of the waters while supporting the deck sections and equipment set on top, above the ocean's reach.

The difference in the functions of the structures may not be apparent to the layman's eye, but there are important differences in each.

The tender-type platform does to some, appear to be nothing more than an offshore structure with a barge moored alongside.

OFFSHORE PRODUCTION PLATFORM SINCE 1947



Source: The Jaramac, J. Ray Mc Dermott & Co., Inc., Summer 1975

This barge is, in reality, a drilling tender and is critical to the total performance of the complex. For economic reasons, the structure has been designed to support only a minimum of the drilling equipment required. All support requirements such as living areas, storage facilities, drilling mud, and large mechancial components of the system are aboard the attending vessel. This vessel "tends" to the operating functions of the drilling rig on the platform. Because these components do not have to be moved onto a strucutre, the required deck space is less, making fabrication time somewhat shorter, and installation and set up time reduced. Applicable in some waters, this kind of structure is not generally used in deeper waters where more extreme conditions make holding the tender alongside more difficult.

On the other hand, the larger self-contained platform attends itself in even the most hostile environments. All components necessary for the day to day operations of the operating areas are contained on the structure. It is a unit independent of the need of assistance for its continual operation, and is resupplied by supply boats, crew boats, and helicopters in good weather and calm sea conditions.

Self-contained platforms can serve a variety of functions. The self-contained drilling platform, with derrick atop, rotates the drill bit deeper and deeper into the earth's crust searching for trapped oil and gas. When a platform is used for drilling only, the well stream must be transported via pipeline to another facility for processing.

Here, then, is when the production platform must be used. This self-contained unit will take the well stream from the reservoir, separate the oil, the natural gas, the water, and other minerals, and ready them for the trip to shore by steel pipelines lying on or buried in the ocean floor. The size of the platform and the required equipment, such as gas compressors, crude oil pumps, or gas and oil separators is determined by the quantity and composition of the well stream.

Today, with advanced design technology, we have placed into service around the world, combination drilling and production platforms. On these massive complexes, the drilling and production sequences take place simultaneously. Using this method of operation, companies save money and valuable time in the production process....

Company engineers and technicians supervise every phase of the hood-up procedures. On these facilities, every pipe, every wire, every switch must be joined, tested and retested before the complex can be turned over to the customer and production can begin.

While the production platforms are being installed, ... pipelaying barges are busy preparing the means of transporting the oil and gas ashore to other platforms or to loading and unloading

facilities. Barges as long as 420 feet, supplied by material barges from onshore bases, lay mile after mile of weight-coated (concrete-coated) pipe onto the seafloor.....

The pipe, ranging in size up to 56 inches, is usually in 40 foot sections called joints. These joints are welded together by passing through as many as seven welding stations on the pipelaying barge where highly experienced welders insure a continuous pipeline.

Each finished weld is then x-rayed to assure flaw free connection and the newly walled area is coated for corrosion protection. It then goes off one end of the barge guided by a support system called a stinger. This device insures a correct curve while the pipe is descending and thus keeps the pipe from excessive bending and possible buckling.

During the laying process .... divers descend into the waters to inspect the pipe and seafloor. These men will make certain that no obstructions have come between the pipe and seafloor, and that the stinger is providing the necessary support to gently lower the pipe at the proper angle to the bottom.

When the line is completed to the platform these divers will again descend for the riser installation. A riser is an extension to the piping system from an offshore production platform. It connects the production facilities with the subsea line.

The pipeline does not simply rest on the seafloor vulnerable to disruption. A small barge, or jet barge, will provide a trench in which the pipe will rest .... passing over the pipe with a specially designed sled, high pressure hoses force air and water beneath the pipe to create a trench into which the pipe settles. The natural movement of the currents on the seafloor surface will cover the line in the trench thus protecting the line from possible damage.

The destination of the pipelines may vary. They may terminate at an offshore gathering station where the oil and gas is further separated and transmitted through other lines to other points.

They may terminate onshore where huge tank farms store the liquid hydrocarbons for distribution to refineries throughout the world.

This distribution too, can be accomplished in various ways depending on the market, the availability of onshore processing facilities and the location of the particular operating companie's facilities.

From the tank farms miles of underground pipelines may carry the oil and natural gas to processing plants. Pipelines

reaching from the tank farms back into the water will allow crude carriers (tankers) to load and unload the oil for distribution to or from other global markets.

These tankers will dock at either multi-berth terminals all allowing for loading and unloading of more than one vessel at a time, or at Single Buoy Mooring Systems.

Tankers moored alongside permanent terminals, in protected areas not subject to severe weather, load or unload cargo through giant arms designed so that the rising or lowering of the ships due to tidal variations or the changing load will not effect the connection.

Tankers can couple with the SBMs in open seas. The free movement of the swivel-top allows for the loading of crude oil regardless of vessel movement due to currents and waves .....

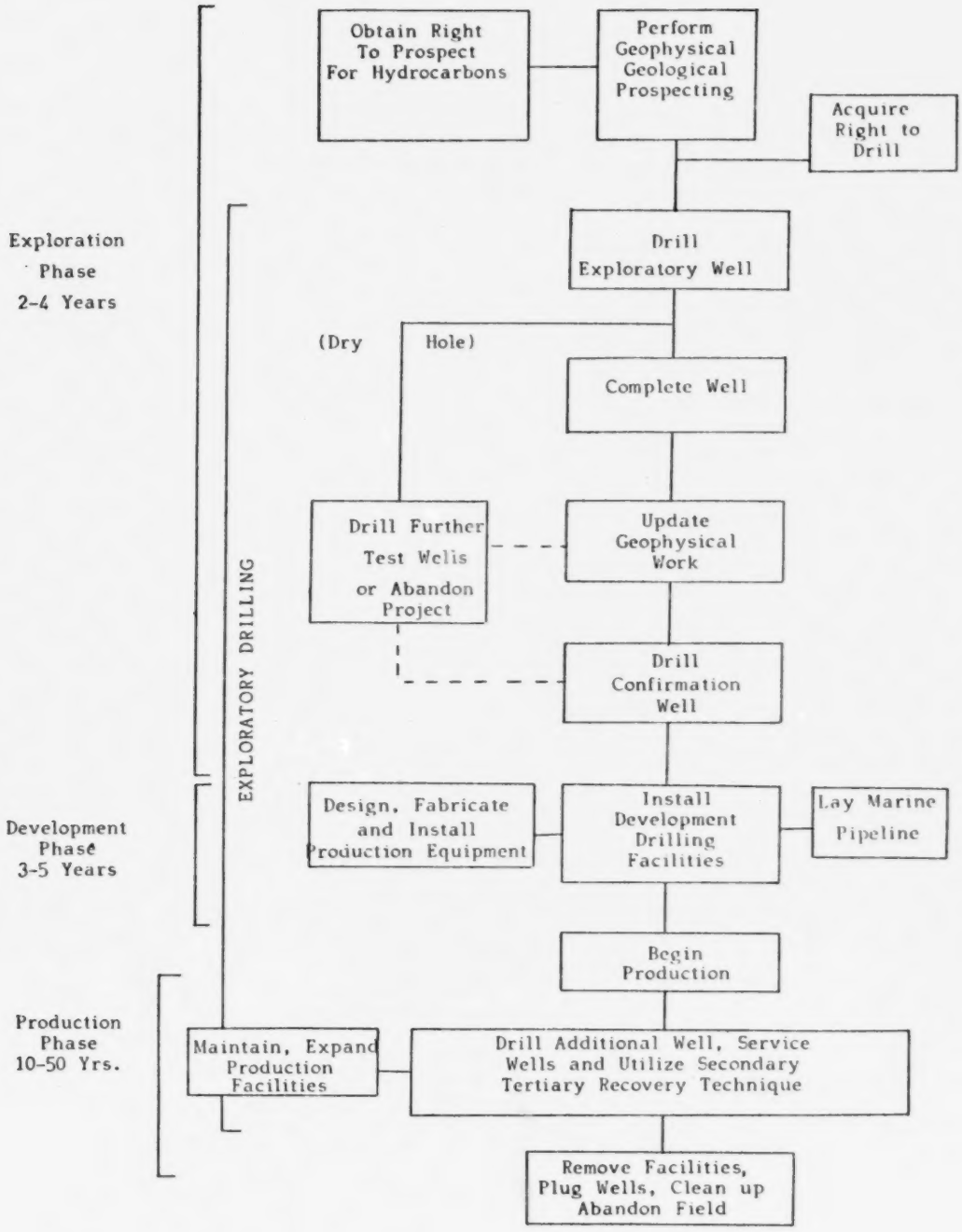
From huge onshore gas processing plants and crude oil processing facilities designed and built by the company, the vital crude and natural gas are then readied for final application. From these plants for the oil, gas and chemical industries, will flow the materials needed for gasoline, motor oil, synthetic fabrics, plastics, asphalt and the innumerable end products we derive from oil.

From here also the natural gas will find its way to the consuming areas of the world to provide clean energy to light our homes, cook our foods, dry our clothes, and become the feed-stock of a myraid of petrochemical industries.

* Source: The Jarama J. R. McDermott & Co., Inc., Summer '75, Permission of Mr. Hanraman

*** NOTE: This article discusses one production system only. There is no guarantee that this type of system will be utilized in the province.

A RELATIVE TIME FRAME FOR
OFFSHORE PRODUCTION OF HYDROCARBONS


Exploration Phase 2-4 Years
Development Phase 3-5 Years
Production Phase 10-50 Yrs.
EXPLORATORY DRILLING
Obtain Right To Prospect For Hydrocarbons
Perform Geophysical Geological Prospecting
Acquire Right to Drill
Drill Exploratory Well
(Dry Hole)
Complete Well
Drill Further Test Wells or Abandon Project
Update Geophysical Work
Drill Confirmation Well
Design, Fabricate and Install Production Equipment
Install Development Drilling Facilities
Lay Marine Pipeline
Begin Production
Maintain, Expand Production Facilities
Drill Additional Well, Service Wells and Utilize Secondary Tertiary Recovery Technique
Remove Facilities, Plug Wells, Clean up Abandon Field

In preparation of these brief notes, we gratefully acknowledge the assistance of the following people:

Rupert Clarke, Department of Labour and Management
Province of Newfoundland and Labrador

Peter Furlong, Department of Industrial Development,
Province of Newfoundland and Labrador

Gordon Gosse, Department of Mines and Energy
Province of Newfoundland and Labrador